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# ABUNDANCE AND TOTAL ALLOWABLE LANDED CATCH FOR THE ADMIRALTY INLET NARWHAL STOCK IN 2010

*Narwhal* Monodon monoceros
*© R. Phillips*

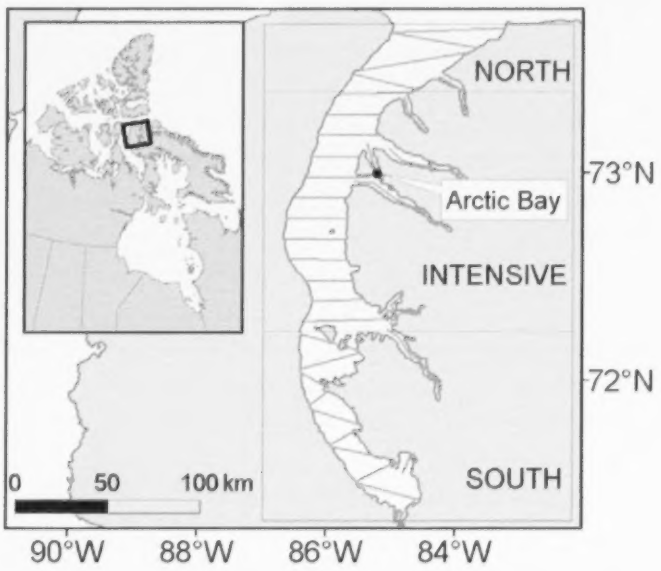


*Figure 1. Study area, stratum boundaries and visual survey plan. Note: the boundaries of the Fjord stratum are not outlined but these extended to the mouths of the fjords (from Asselin and Richard 2011).*

**Context**

*The Baffin Bay narwhal population is composed of at least four summering aggregations in Canadian waters that are considered separate stocks for management purposes. One of them is known as the Admiralty Inlet stock. As it is subject to a subsistence hunt, predation by killer whales and climate-induced habitat changes, an accurate estimate of abundance is needed. The most recent estimate from 2003 was thought to be biased so a new aerial survey was undertaken by Fisheries and Oceans Canada (DFO) in August 2010. This science advisory report presents the new abundance estimate, Potential Biological Removal and calculated Total Allowable Landed Catch for the Admiralty Inlet stock.*

## SUMMARY


- The previous surveys of Admiralty Inlet were conducted in August 2003. At that time, it was estimated that 5,362 (95% confidence interval 1,920-12,199) narwhals were summering there. The 2003 surveys had large confidence intervals and were thought to be biased by weather conditions and severe clumping of narwhals.
- In August 2010, two aerial surveys of Admiralty Inlet were completed using an adaptive sampling plan which combined visual line-transect sampling of the entire Inlet and aerial photography of aggregations.




Canada

- Combining the two survey results from 2010, using an effort-weighted mean, gave an estimate of 18,049 (coefficient of variation 0.23, 95% confidence interval 11,613-28,053) narwhals.
- For the Admiralty Inlet stock, Potential Biological Removal (PBR) for the combined 2010 estimate was 299 narwhals. The total allowable landed catch (TALC), corrected to include hunting losses, was 233 narwhals.
- This stock summers in Admiralty Inlet, winters in Baffin Bay and migrates between these areas during spring and fall. The PBR and TALC apply over the whole range of the stock.

## BACKGROUND

The Baffin Bay narwhal population is composed of at least four Canadian summering aggregations. Admiralty Inlet is home to one of these aggregations and, for management purposes, these animals are considered a separate stock (Richard 2010). Previously surveyed in 2003, the estimate of abundance for this stock was 5,362 (95% confidence interval (CI) 1,920-12,199) (Richard et al. 2010). However, this estimate had large confidence intervals and was thought to be negatively biased due to weather conditions and extreme off-transect clustering of narwhals during that survey. A new survey was undertaken in August 2010 to obtain a more accurate estimate of abundance for the Admiralty Inlet narwhal stock, and to update the TALC using the new abundance estimate.

## ANALYSIS

### Abundance of Admiralty Inlet Narwhals

The study area was Admiralty Inlet on northwestern Baffin Island; it was divided into four strata (Figure 1). An east-west parallel line design was used for the Intensive stratum and a zigzag design for the North and South strata (Figure 1). Reconnaissance surveys were flown up the middle of adjoining bays and inlets, to the mouths of the fjords, for the Fjord stratum. The surveys were conducted from a DeHavilland Twin Otter (DH-6) equipped with bubble windows (survey details are described in Asselin and Richard 2011). The visual survey had two observers on each side of the plane. Two digital cameras were operated in an optical-glass-covered camera hatch at the rear of the plane for the photographic surveys.

As large narwhal aggregations were encountered during previous surveys in Admiralty Inlet, resulting in less precise stock estimates, an adaptive survey plan was used in 2010. The plan was to conduct stratified, systematic, visual line-transect aerial surveys throughout the study area, but, when large aggregations (>50 animals) were encountered, photographic surveys would be done over the aggregation, and the area of aggregation removed from calculations of the systematic survey estimate.

The first visual survey was flown on 7-8 August 2010; it covered all but the North and Fjord strata. A large narwhal aggregation was encountered and photographed along the east shore of Admiralty Inlet off the northern-most transect in the Intensive stratum on 7 August 2010. A second (smaller) aggregation was encountered along the west shore off the southern-most transect in the South stratum on 8 August 2010 but an aircraft malfunction prevented those animals from being photographed. The second visual survey was flown on 10-11 August 2010; it covered all strata.

Distance 6.0, a Windows-based computer package for designing and analyzing distance sampling surveys of wildlife populations, was used to analyze the sighting data. Numbers of narwhals reported by the survey observers were corrected for perception bias and availability bias (survey analysis described in Asselin and Richard 2011). Numbers of narwhals counted in the photographs from the first survey were also corrected for availability bias.

Summing the totals of the first visual survey and photographed area resulted in a total estimate for the first survey of 24,398 (coefficient of variation (CV) = 0.25) (Table 1). The second visual survey, during which no large aggregations of narwhals were identified, produced a total estimate of 13,729 (CV=0.40) (Table 1). Due to their large CVs, the difference between the two survey estimates was not statistically significant. However, non-random movements of narwhals were observed within the study area during the two surveys: mainly southerly during the first survey (on August 7) and mainly northerly during the second survey (on August 10). Consequently, the abundance estimate for the first survey may have been positively biased by the movement of narwhals in the same general direction (north to south) as the plane surveyed the intensive stratum. Similarly, the abundance estimate for the second survey may have been negatively biased by animal movement in the opposite direction (south to north) of the survey plane in the Intensive stratum. The difference in abundance estimates from the two surveys was, therefore, deemed to be due to sampling variation from the clustering and movements of narwhals, not real changes in stock size. So the two abundance estimates were averaged using an effort-weighted mean, where effort was measured by the area covered over the total area of the survey. This resulted in a final stock estimate of 18,049 (95% CI 11,613-28,053) (Table 1).

*Table 1. Narwhal abundance estimates for the two surveys and the weighted mean abundance estimate for Admiralty Inlet.*

| | Confidence limit 2.5% | Mean | Confidence limit 97.5% | CV |
|---|---|---|---|---|
| **First survey** | | | | |
| Visual | 13,551 | 22,763 | 38,236 | 0.27 |
| Photo | 1,498 | 1,635 | 1,785 | 0.04 |
| *Total* | *15,022* | *24,398* | *39,626* | *0.25* |
| **Second survey** | | | | |
| *Visual (Total)* | *6,437* | *13,729* | *29,284* | *0.40* |
| **Average** | **11,613** | **18,049** | **28,053** | **0.23** |

## Total Allowable Landed Catch

PBR is an accepted method of making a conservative estimate of sustainable human-induced mortality (DFO 2008). Based on the 2010 Admiralty Inlet survey results, the estimated PBR for this stock is 299 narwhals (Asselin and Richard 2011). TALC is PBR divided by a Loss Rate Correction. Using a Loss Rate Correction of 1.28 (Richard 2008) yielded a TALC of 233.

$$TALC = \frac{PBR}{LRC}$$

Where:

$PBR = 0.5 \times R_{Max} \times \hat{N}_{Min} \times F_r$

$LRC$ = Loss Rate Correction

$R_{Max}$ = Maximum rate of increase for the stock

$\hat{N}_{Min}$ = 20th percentile of the log-normal distribution of the total (corrected) stock estimate (i.e., 14,936 narwhals)

$F_r$ = Recovery factor

As the maximum rate of increase for the stock ($R_{Max}$) is unknown, the default of 0.04 for cetaceans was used. The recovery factor ($F_r$) was set at 1.0, a value considered appropriate for a stock that shows no sign of depletion.

## Sources of Uncertainty

There were a number of sources of uncertainty associated with the estimation of stock size. The correction factor for availability bias has a large effect on the estimated size of the stock but has a small variance because it is based on the average diving behaviour of a small number of narwhals instrumented with time-depth recorders. It is possible that the mean proportion of time those animals spent at the surface does not fully account for the variation in behaviour of Admiralty Inlet narwhals during the surveys. Further research is needed to determine if the coefficient of variation of narwhal diving behaviour in the whole population is greater than the current estimate of 4%. The impact of movement of narwhals during surveys on the estimate is also uncertain, although having flown two surveys allowed for an average that may have reduced this bias. Extreme clumping of narwhals likely contributed to differences in the abundance estimate between the two surveys and is a major source of uncertainty. In addition, it is uncertain as to the degree of bias the adaptive post-stratification contributed to the estimation of stock size.

Uncertainty in the calculation of TALC comes from using a fixed Loss Rate Correction (1.28) derived from hunts in a number of Nunavut communities. Independent hunt loss rates should be collected for Admiralty Inlet to evaluate whether the loss rates used are appropriate here.

## CONCLUSIONS AND ADVICE

Two visual aerial surveys, combined with photographic surveys of large aggregations, were flown in August 2010. The surface-visible estimates from both surveys were adjusted for submerged whales and whales missed by observers. The two abundance estimates were averaged using an effort-weighted mean to produce a final stock estimate of 18,049 narwhals (95% CI 11,613-28,053). On the basis of this survey result, and a fixed Loss Rate Correction of 1.28, the PBR calculation (299 narwhals) was converted to a TALC of 233 narwhals. The previous advice for the Admiralty Inlet stock was a PBR and TALC of 36 and 28 narwhals, respectively (DFO 2008). The

change in advice reflects the significant difference between the abundance estimates derived from the negatively-biased 2003 survey and the 2010 survey.

## SOURCES OF INFORMATION

This Science Advisory Report is from the March 30, 2011 of the National Marine Mammal Peer Review Committee (NMMPRC): 2010 Admiralty Inlet narwhal survey. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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